NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

January 31, 2014

SYSTEMS GROUP CHAIRMAN'S FACTUAL REPORT ADDENDUM 1

DCA13MA120

A. ACCIDENT

Location:	San Francisco, CA
Date:	July 6, 2013
Time:	11:28 PDT
Aircraft:	Boeing 777-200ER

B. SYSTEMS GROUP

Chairman:	Adam Huray National Transportation Safety Board Washington, DC
Member:	Ken Fairhurst Federal Aviation Administration Renton, WA
Member:	John Herndon Federal Aviation Administration Houston, TX
Member:	Jung Ho Kim Aviation and Railway Accident Investigation Board Seoul, South Korea
Member:	Hae Seok Seo Asiana Airlines Seoul, South Korea
Member:	Dennis Asheim Boeing Seattle, WA
Member:	Jay Eller Honeywell Phoenix, AZ

C. SUMMARY

On July 6, 2013 at 11:28 am Pacific daylight time, a Boeing 777, registration HL7742, operated by Asiana Airlines as flight 214, struck the seawall short of runway 28L at San Francisco International Airport. The airplane was destroyed by impact forces and fire. Three of the 291 passengers were fatally injured. The flight was a regularly scheduled passenger flight from Incheon International Airport, Seoul, Korea, and was operated under the provisions of *14 Code of Federal Regulations Part 129*. Visual meteorological conditions prevailed at the time of the accident.

This addendum documents the research performed by the Systems Group regarding the Aircraft Communications Addressing and Reporting System communications and the Engine Indication and Crew Alerting System messages. It also documents additional component examinations that occurred following the release of the initial Systems Group Chairman's Factual Report.

D. ASIANA AIRCRAFT COMMUNICATIONS ADDRESSING AND REPORTING SYSTEM:

Asiana uses their own customized version of Aircraft Communications Addressing and Reporting System (ACARS). ACARS is a data link system to a ground station that allows for text based communications. Asiana ACARS has interfaces with the Aircraft Condition Monitoring System, Flight Management Computer, and Central Maintenance Computer. ACARS automatically sends information from these systems to the ground station when customized criteria are met. ACARS can also send interactive text communications between the crew and ground station.

Asiana ACARS sends correlated and non-correlated maintenance messages from the Central Maintenance Computer at the time of occurrence but within the limitations of the system. A correlated maintenance message is one that has an associated flight deck effect. A non-correlated maintenance message does not have an associated flight deck effect. Asiana reported that there were no correlated or non-correlated maintenance messages reported through ACARS during the accident flight.

E. ENGINE INDICATION AND CREW ALERTING SYSTEM:

At approximately time 11:27:39 a caution alert (quadruple chime) was recorded on the cockpit voice recorder. There are 75 Engine Indication and Crew Alerting System (EICAS) messages that could result in an aural caution alert. Of these 75, the only message that could be confirmed as meeting all the parameters required for activation based on available data was an "Airspeed Low" message. For details regarding the conditions required to activate an "Airspeed Low" EICAS message see sections 2.3 and 3.3 of the Aircraft Performance Group Study located in the public docket for this accident.

F. COMPONENT EXAMINATIONS:

F.1 Thrust Lever Assembly, Left Autothrottle Assembly, and Right Autothrottle Assembly:

F.1.1 Component Removal:

The Thrust Lever Assembly, Left Autothrottle Assembly, and Right Autothrottle Assembly were removed from the aircraft after the aircraft was recovered from the runway. The removed Thrust Lever Assembly included the left and right thrust levers including the attached Takeoff/Go-Around and autothrottle disconnect switches. Each removed Autothrottle Assembly included a servomotor, gearbox, brake assembly, and resolver transmitter assembly. The wiring harnesses for all components were disconnected at the connectors and remained attached to the components. All electrical connections were checked on the aircraft and found to be secure prior to removal.

The throttle quadrant dust covers were removed as a separate activity that occurred prior to the removal of the above components. At the time the dust covers were removed there was heavy dust and no foreign object debris identified within the throttle quadrant mechanism. At the time of component removal two sections of dust covers were discovered within the throttle quadrant mechanism. These two dust cover sections were missing from the rest of the recovered dust cover sections and demonstrated soot patterns that were similar to the other recovered dust cover sections. All levers on the throttle quadrant were moved by hand prior to the removal of the two dust cover sections found inside the throttle quadrant. All levers on the throttle quadrant had full range of travel and felt typical except for the right Alternate Pitch Trim lever. This lever was jammed in the aft position. The Alternate Pitch Trim levers are normally connected to cables that run the length of the airplane to the stabilizer compartment.

F.1.2 Examination and Functional Test:

The System's group met at the Boeing Fabrication facility in Portland, OR, on January 16-17, 2014 for the examination of the Thrust Lever Assembly, Left Autothrottle Assembly, and Right Autothrottle Assembly. Representatives from Asiana, Boeing, and the NTSB were present.

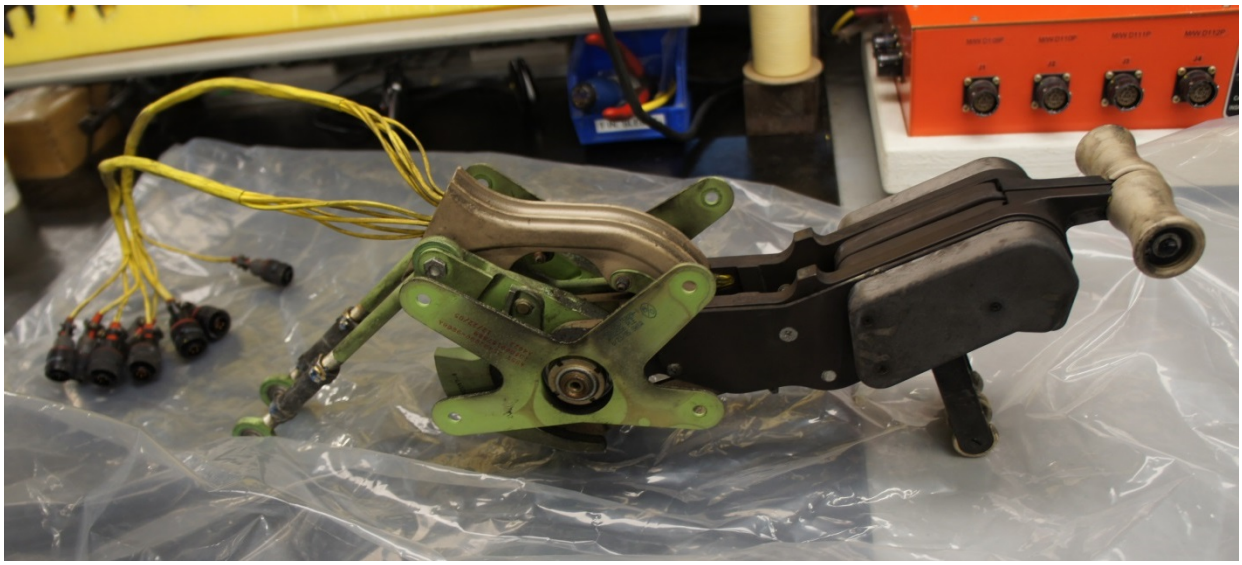

Figure 1: Thrust Lever Assembly

Figure 2: Left Autothrottle Assembly

Figure 3: Right Autothrottle Assembly

The label information from the components was as follows:

Thrust Lever Assembly:
P/N: 254W2000-9008A
ID Number: 000107889

Left Thrust Lever Assembly:
P/N: 254W2001-9A
ID Number: 000107438

Right Thrust Lever Assembly:
P/N: 254W2001-10A
ID Number: 000105467

Left Autothrottle Servo Motor:
P/N: 304RAA1
S/N: 1315
Modification Level: 1
DMF: Nov 05

Left Gearbox:
P/N: illegible
PO Number: illegible

Left Brake Assembly:
P/N: 254W4101-5
PO Number: 000106371

Left Resolver Transmitter:
P/N: S254N101-4
S/N: 5040

Right Autothrottle Servo Motor:
P/N: 304RAA1
S/N: 1310
Modification Level: 1
DMF: Oct 05

Right Gearbox:
P/N: illegible
PO Number: illegible

Right Brake Assembly:
P/N: 254W4101-6
PO Number: 000108374

Right Resolver Transmitter:
P/N: S254N101-4
S/N: 5022

The components were removed from a secure room and removed from the packaging. A visual inspection was performed and the exterior of the components appeared sooty but physically were in good condition (see Figures 1, 2, and 3). All pins at the wire connectors appeared straight and clean. The locking mechanism on Connector DM73202A was damaged and required excessive force to lock. This connector connects the wiring harness for the right resolver transmitter. All components were lightly cleaned and installed into a known good control stand. The complete control stand was then subjected to the production Control Stand Assembly Functional Test per Boeing's document 254W1100, Sheet 6, Rev A, Advance Drawing Change Notice numbers 1, 2, and 3. The portions of the functional test relevant to the autothrottle function, throttle lever function, Takeoff/Go-Around switch operation, and autothrottle disconnect switch operation were performed. The results were as follows:

Test Section	Test Name	Result
5.4.1.1.1	FWD THRST LEVER TRAVEL	Pass
5.4.1.1.2	FTL TRAVEL - CAM FOLLOWER	Pass
5.4.1.1.3	REVERSE THRUST LEVER TRAVEL	Pass
5.4.1.2.1	FORWARD THRUST LEVER LOADS	Pass
5.4.1.2.2	REVERSE THRUST LEVER LOADS	Pass
5.4.2.1.1	Autothrottle Discnct Sw. TRAVE	Pass
5.4.2.1.2	AutoThrottle Disconnect - FREE	Pass
5.4.2.1.3	LEFT AutoThrottle Disconnect	Pass
5.4.2.1.4	RIGHT AutoThrottle Disconnect	Pass
5.4.2.2.1	Sync Shft Lock Valve Sw. FREE	Pass
5.4.2.2.2	Left RTL Sync Shft Lock Valve	Pass
5.4.2.2.3	Right RTL Sync Shft Lock Valve	Pass
5.4.2.3.1	TO/GA Switches TRAVEL	Pass
5.4.2.3.2	TO/GA SWITCHES - FREE	Pass
5.4.2.3.3	LEFT TO/GA SWITCH	Pass
5.4.2.3.4	RIGHT TO/GA SWITCH	Pass
5.4.3.1	LEFT TLA RESOLVER	Pass
5.4.3.5	RIGHT TLA RESOLVER	Fail
5.5.1	Switch Pack	Pass
5.5.2.1	Reverse Thrust DCV Sw. Idle	Pass
5.5.2.2	Right DCV Switch	Pass
5.5.2.3	Left DCV Switch	Pass
5.5.3.1	Autobrake Inhibit Sw. FREE	Pass
5.5.3.2	Left AutoBrake Inhibit Sw.	Pass
5.5.3.3	Right AutoBrake Inhibit Sw.	Pass
5.6	AutoThrottle Actuators	Pass

During the test setup, the A and B channel readings for the right resolver transmitter assembly differed by 2.59 degrees with the throttle levers at idle, 2.62 degrees with the throttle levers at the full forward position, and 2.60 degrees with the throttle levers at the full reverse position. In each case the channel B reading was the greater of the two. This condition did not allow for rigging both channels within acceptable test tolerances. For the functional test, the thrust lever linkages were adjusted such that channel B in the right resolver transmitter assembly was within tolerance of the nominal value for the lever placed in the aft stop position. These linkages are normally adjusted during control stand build and if necessary on the airplane for proper rigging.

The control stand passed all sections of the performed tests except for 5.4.3.5 (Right Thrust Lever Angle Resolver). This test failed because the right thrust lever angle for channel A was not reading within the allowed range after the thrust lever linkages were adjusted to bring the channel B thrust lever angle within acceptable test tolerances. With the throttle levers at idle the right thrust lever angle for channel A read 31.497 degrees (test requirement was 34.0 +/- 0.25

degrees); with the throttle levers at the full forward position the right thrust lever angle for channel A read 81.699 degrees (test requirement was 84.7 +/- 1 degrees); and with the throttle levers at the full reverse position the right thrust lever angle for channel A read 2.593 degrees (test requirement was 5.0 +/- 1 degrees). The root cause of the offset between the A and B channel thrust lever angle readings from the right resolver transmitter assembly was not determined.

The 777-200 aircraft is designed such that if both channels from the same resolver transmitter assembly are valid than the autothrottle system will receive and use the higher of the two values. If the difference between the two channels is greater than 2 degrees for more than 2 seconds a non-correlated maintenance message will occur. Non-correlated maintenance messages are reported via Asiana's ACARS. Asiana confirmed that there were no maintenance messages related to a resolver transmitter channel disagree reported through ACARS in their available history dating back to June 20, 2013. Review of the FDR at time 11:19:48 during the accident flight revealed that the recorded value for the left engine thrust lever angle was 33.75 degrees and the recorded value for the right engine thrust lever angle was 34.10 while both thrust levers were at the idle stop. Both of these readings are within the expected value of 34.0 +/- 0.25 degrees when the levers are at the idle stop as required by the production Control Stand Assembly Functional Test.

F.1.3 Service History:

Boeing Portland had no service records for the removed Thrust Lever Assembly, Left Autothrottle Assembly, or Right Autothrottle Assembly.

F.2 Enhanced Ground Proximity Warning System:

The Mark V EGPWS is an Enhanced Ground Proximity Warning System (EGPWS) that provides aural and visual alerts and warnings to prevent Controlled Flight into Terrain (CFIT) and for low altitude windshear conditions. The EGPWS uses aircraft inputs such as position, attitude, airspeed, and glideslope along with an internal terrain and obstacle database to predict potential conflicts in the aircraft's projected flight path. Audible alert messages and visual clues alert the crew if a potential collision is detected. The EGPWS contains non-volatile memory that records information related to system faults, warnings, and airplane status.

The EGPWS is designed to protect against seven different scenarios categorized by modes. Mode 1 is excessive descent rate, Mode 2 is terrain closure rate, Mode 3 is descent after takeoff, Mode 4 is unsafe terrain clearance, Mode 5 is excessive deviation below glideslope, Mode 6 is advisory callouts, and Mode 7 is windshear protection. For details regarding each mode during the accident approach to landing see "EGPWS Warning Analysis Provided by Honeywell" located in the public docket for this accident.

The System's group met at the Honeywell facility in Redmond, WA on January 14, 2014 for the examination of the Enhanced Ground Proximity Warning System (EGPWS) removed from the event airplane. Representatives from Asiana, Honeywell, Boeing, and the NTSB were present.

Figure 4: Enhanced Ground Proximity Warning System

The label information for the EGPWS was as follows:

MFG: Honeywell
P/N: 965-0976-003-218-218
S/N: 22026
MFD: 0516 (year/week)
MOD: 13

F.2.1 Visual Examination:

The EGPWS was removed from a secure locker and removed from the packaging. A visual inspection was performed and the exterior of the unit appeared sooty around the ventilation holes but otherwise was in good condition (see Figure 4). All cover screws were flush with the cover. All connector pins appeared straight and the tamper seals were intact. The unit did not appear to have any loose internal components. "M34004" was written with permanent marker on the side of the unit.

The EGPWS cover screws were removed and the three internal circuit card assemblies were removed. The circuit card assemblies appeared in good condition with no anomalies noted. The circuit card assemblies were inserted back into the unit for the remainder of the examination.

F.2.2 Non-volatile Memory Download:

The EGPWS was connected to an engineering test bench and the non-volatile memory (NVM) was downloaded per Honeywell procedure 060-4199-115, Rev D. The NVM confirmed the Terrain Database loaded to the unit was version 467 and the Boot Software was version B103.1. The unit was in "On Ground" mode when it was powered on the test bench. Under normal operation the EGPWS would require a valid radio altitude signal of less than 5 ft and an aircraft speed below 60kts to transition to "On Ground" mode.

A takeoff record from Incheon International Airport was recorded at EGPWS total powered time of 22175:25:56. A takeoff record is created and stored to NVM when the aircraft transitions through approximately 25 ft radio altitude during takeoff. A landing record for San Francisco International Airport was recorded at EGPWS total powered time of 22185:59:49. A landing record is created and stored to NVM when the aircraft transitions through approximately 50 ft radio altitude during descent. The position uncertainty for the EGPWS was recorded as 0.009 nautical miles at the time of the landing record. There were no faults, warnings, or events recorded in the EGPWS NVM for the time between the takeoff record and the landing record. There were no "In Air" faults recorded at any time during the accident flight leg and the most recent "In Air" fault stored in NVM occurred 34 flight legs prior to the accident flight.

There were multiple records in NVM for the accident flight leg that occurred after the landing record was recorded. The flight leg counter increments at each takeoff and therefore any records that occurred during the impact sequence and/or during power up on the test bench would be recorded to the accident flight leg. There was a ground fault titled GPWS INOP that occurred with a time stamp of 22186:00:02 and multiple ground faults were recorded with a time stamp of 22186:00:52. There was a TERRAIN NOT AVAILABLE ON record with a time stamp of 22185:59:59. There was a TERRAIN AWARENESS AND DISPLAY CAUTION TERRAIN and a TERRAIN AWARENESS AND DISPLAY PULL UP warning recorded at time 22186:00:10. The associated data for the TERRAIN AWARENESS AND DISPLAY CAUTION TERRAIN and TERRAIN AWARENESS AND DISPLAY PULL UP warnings appeared to be invalid and Honeywell advised that the presence of these warnings in the NVM is a known nuisance fault.

F.2.3 Functional Test:

A functional test was performed on the unit per the manufacture's ATP 076-0879-002, Rev U. The unit was connected to an engineering test bench. The unit passed all portions of the test.

F.2.4 Service History:

Honeywell identified one service order in their records for this unit. On 12-09-2008 Asiana Airlines returned the unit to Honeywell due to a ground proximity EICAS message. Honeywell Singapore replaced the A2 circuit card assembly and installed the latest hardware, software, and terrain database modifications. The repair date differs from the date of 17 Dec 07 written on the service sticker attached to the unit; however, all digital records indicate that 12-09-2008 is correct.

F.3 Airplane Information Management System:

The Airplane Information Management System (AIMS) has two cabinets which do the calculations for other avionics systems. To do these calculations, each AIMS cabinet has a cabinet chassis, four input/output modules, and four core processor modules. The input/output modules transfer data between the software functions in the AIMS core processor modules and external signal sources. The core processor modules supply the software (called functions) and hardware to do the calculations for several avionic systems. To keep the necessary separation between the functions, each function is partitioned. The partitions permit multiple functions using the same hardware to be in the same core processor module.

The two AIMS core processing modules part number 4089300-901 contain the computing functions related to Thrust Management, Flight Management, Aircraft Condition Monitoring, Navigation, Data Conversion Gateway, Flight Information Data Output, and Built-In Test Equipment (BITE) Monitor on the aircraft. There is one module for the left AIMS system and one module for the right AIMS system.

The modules part number 4089300-901 contain limited NVM related to the core module BITE history, Flight Management function, and Data Conversion Gateway function. Faults are written to NVM when the system determines the aircraft is in the "Taxi In" phase of flight. The "Taxi In" determination is defined as the aircraft on the ground, airspeed less than 80 kts, and with at least one engine running. The modules record core BITE history (BITE Monitor function) to NVM for the last 64 flight legs. The modules record BITE history in NVM for the Flight Management function and Data Conversion function for the current leg and also for the last flight leg for which a fault occurred. BITE history for the other module functions (including Thrust Management function) are lost when power is removed from the module.

The group met at the Honeywell facility in Phoenix, AZ on January 20-21, 2014 for the examination of the two AIMS modules part number 4089300-901 removed from the event airplane. Representatives from Asiana, Honeywell, Boeing, and the NTSB were present.

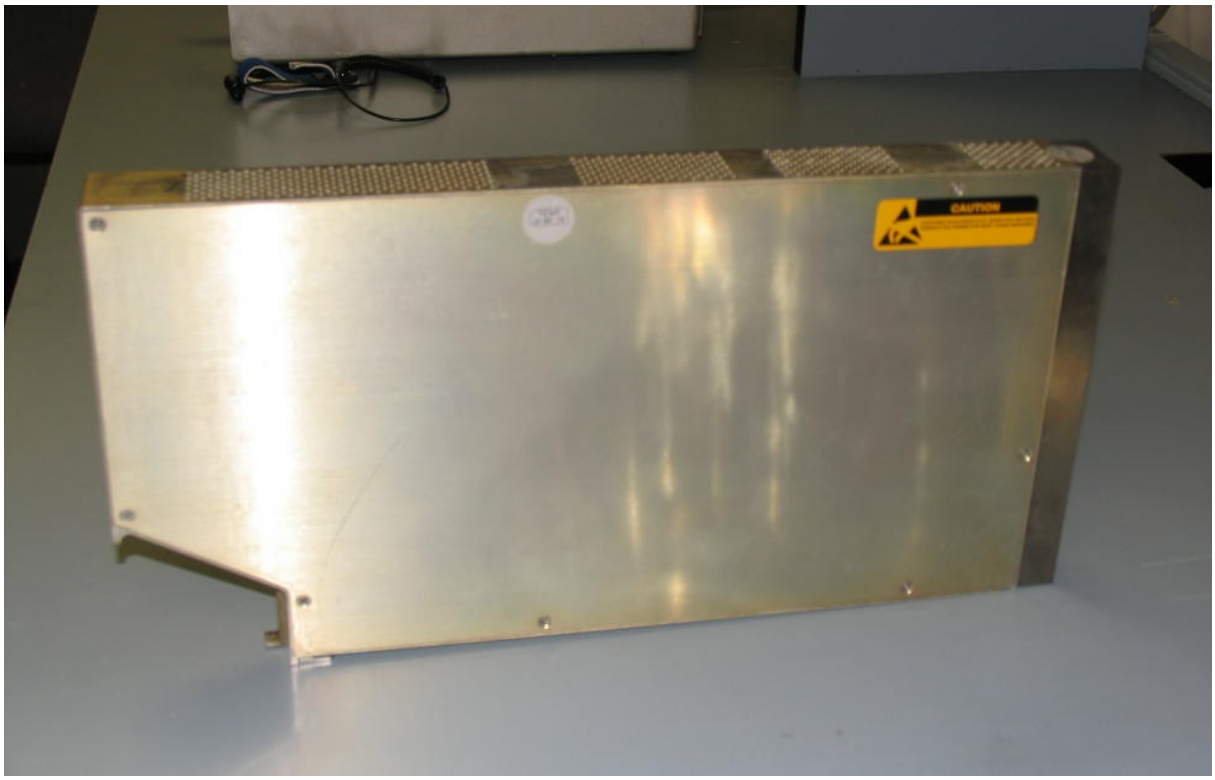

Figure 5: AIMS Module Example (S/N: 31868491)

The label information for the two AIMS modules was as follows:

MFG: Honeywell
P/N: 4089300-901
S/N: 31868491 and 31875691
MFD: 102005
MOD: None marked

F.3.1 Visual Examination:

The two AIMS modules were removed from a secure locker and removed from the packaging. A visual inspection was performed and the exterior of both units appeared dirty and/or sooty around the ventilation holes but otherwise were in good condition (see Figure 5). All connector pins appeared straight and the original manufacturing tamper seals were intact. Serial Number 31868491 was labeled as the Left AIMS module and Serial Number 31875691 was labeled as the Right AIMS module with permanent marker on the sides of each unit.

F.3.2 Non-volatile Memory Download:

Resistance checks were performed to ensure it was safe to apply power to the units. The units passed all resistance checks and then were subjected to the manufacturer's NVM download procedure as defined in Honeywell document C72-6631-005, Rev A, Sections 6 and 7.

The NVM download for Serial Number 31868491 revealed that the unit was operating with software HNP5A-AL05-1005. The Core BITE history did not contain data for the accident flight. The most recent flight leg with faults was three flight legs prior to the accident flight and contained faults “RAM Correctable EEPROM Write Failure”, “BIPM WOWA and ARINC629 WOW Right Differ”, and “BIPM WOWB and ARINC 629 WOW Left Differ”. These are typically considered to be nuisance faults by the manufacturer. The Flight Management BITE history did not contain data for the accident flight. The most recent flight leg with faults in the Flight Management NVM was from June 12, 2013 and contained a single fault “ONEHERTZ Heartbeat Check”. A Heartbeat fault would trigger a warm start of the Flight Management partition of the AIMS module and the system would continue operation with no flight deck effect. The Data Conversion Gateway BITE history did not contain any faults.

The NVM download for Serial Number 31875691 revealed that the unit was operating with software HNP5A-AL05-1005. The module core BITE history did not contain data for the accident flight. The most recent flight leg with faults was nine flight legs prior to the accident flight and contained the fault “RAM Correctable EEPROM Write Failure”. This fault is typically considered to be a nuisance fault by the manufacturer. The Flight Management BITE history did not contain data for the accident flight or for any prior flight legs. The Data Conversion Gateway BITE history did not contain any faults.

F.3.3 Functional Test:

A functional test was performed on both units per the manufacture’s Engineering Specification IT4089300-901, Rev F. The units passed all portions of the functional test.

F.3.4 Service History:

Honeywell had no records of repair for either module.

Adam Huray
Mechanical Engineer